APGC-TDR-62-57

Structural Compatibility Test of M61 Gun/Linkless Feed Subsystem and F-105D Aircraft

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DEPUTY FOR AIRCRAFT AND MISSILES TEST

AIR PROVING GROUND CENTER

AIR FORCE SYSTEMS COMMAND • UNITED STATES AIR FORCE

EGLIN AIR FORCE BASE, FLORIDA

FOREWORD

This test, APGC Project 306AZ16, was conducted under the authority contained in message ASZFO-4-8-26 from the F-105 System Program Office, dated 27 August 1961, as amended. Testing commenced on 20 November 1961 and was completed on 13 July 1962.

The following personnel were responsible for the conduct of this test and/or the preparation of this report:

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Catalog cards may be found in the back of this document.

ABSTRACT

The M61 gun/linkless feed subsystem was designed to provide the F-105D with a compact, self-contained, high rate firing capability. The primary object of this test was to determine the effects of this subsystem on the structural integrity of the aircraft nose structure. As a result of this test, it is concluded that the subsystem imposes no serious structural limitations on the F-105D; however, because of the effects of gun gas, the firing envelope of the aircraft is limited.

Modifications to the basic M61 gun/linkless feed subsystem (oiler, undercut barrels, modified blast tube, and interrupter relay) were tested and found to be satisfactory. There is a problem in maintaining the M61 gun/linkless feed subsystem since 134 man-hours are required to repair the subsystem after a stoppage occurs.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

J. E. Roberts

J. E. ROBERTS
Major General, USAF
Commander

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SECTION 1 - INTRODUCTION

A requirement was established by the F-105 System Program Office (SPO) in message ASZFO-4-8-26, dated 27 August 1961, to investigate the effect of gun fire on the nose structure of the F-105D aircraft. This requirement was precipitated by the discovery of a series of cracks throughout a test nose structure mounted on a hard stand at Republic Aviation Corporation, Farmingdale, Long Island, New York. These cracks were discovered at approximately 50,000 rounds of firing and were estimated to have started propagation between 25,000 rounds and 50,000 rounds of firing.

The objectives of this test were to:

1. Determine the effects of gun firing, throughout the flight envelope, on the nose structure of the F-105D.

2. Obtain maintenance data on the M61 gun/linkless feed subsystem.

3. Determine the firing rate of the M61 gun/linkless feed subsystem.

4. Determine the usefulness of recent modifications to the M61 gun/linkless feed subsystem.

In addition to the basic test, the effects of gun vibration and "g" loading on the pullout plug retaining mechanism of the B-28 internal nuclear weapon were investigated.

SECTION 2 - DESCRIPTION

M61 GUN SYSTEM

The Block IV M61 gun/linkless feed subsystem (Fig. 1) utilized in this test was modified so that it represented the -15RE configuration. In addition, the system included:

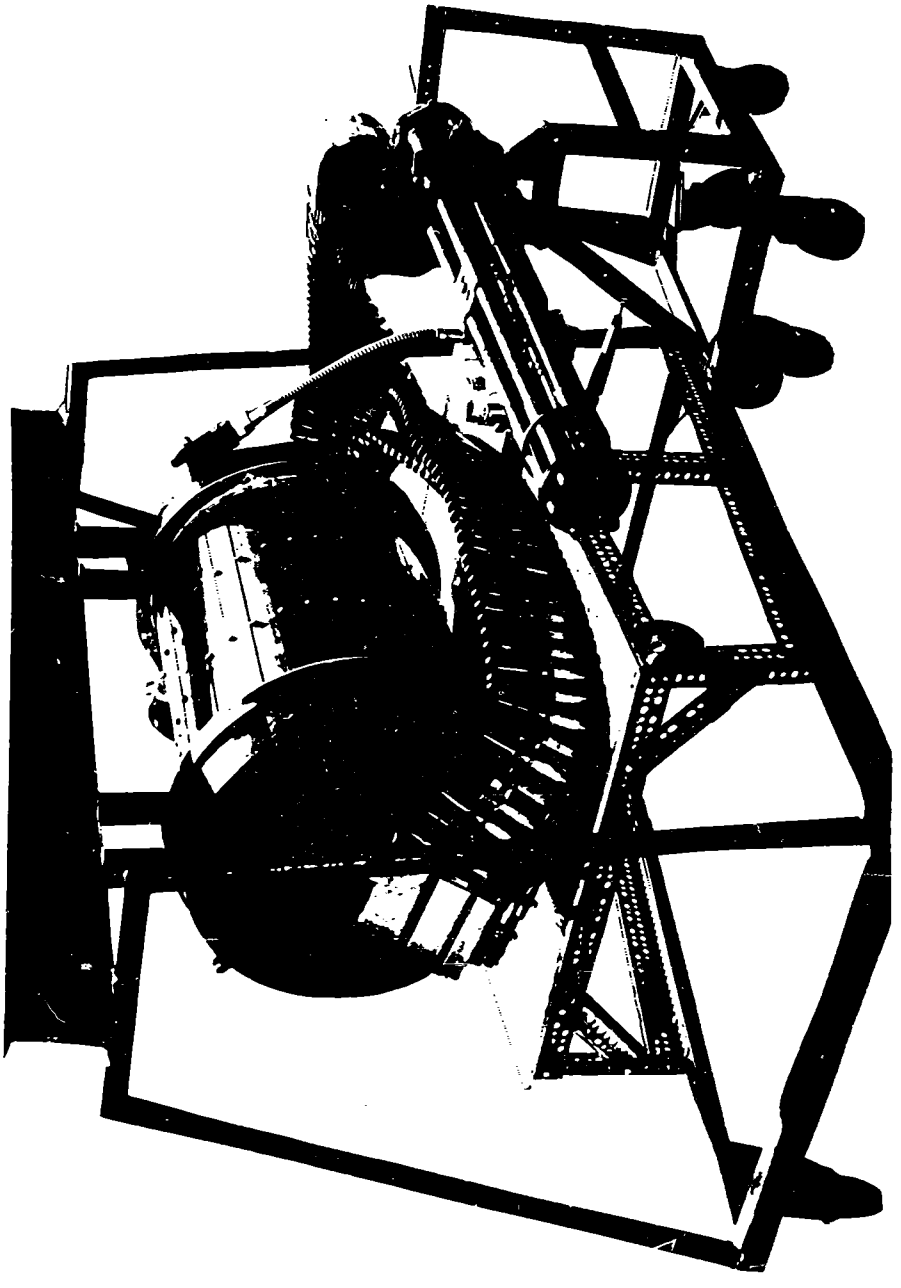

Fig. 1: M61 Gun/Linkless Feed Subsystem.

1. An oiler for lubricating the gun while firing.

2. A gun-firing interrupter switch to prevent system jamming in the event attempts were made to fire the gun without waiting the necessary time for the system to clear.

3. A modified blast tube to prevent burn-through by gun flash.

4. Undercut barrels to facilitate removal of the forward muzzle stabilizer clamp.

F-105D AIRCRAFT

The F-105D-1RE aircraft, SN 58-1147, had both the air turbine motor and the fuel pump bleed line installed, as outlined in Technical Orders 1F-105-576 and 1F-105-553, to alleviate engine surges. The aircraft was maintained by the Air Proving Ground Center.

SECTION 3 - TEST PROCEDURES

DATA COLLECTION

Flight data were recorded by using right and left over-the-shoulder cameras to record readings on the instrument panel. An oscillograph was used to record gun-firing voltage and a-c power against a time scale to yield firing rate. Mission cards were also filled out by pilots to record mission parameters.

PHOTOGRAPHY

Photographic coverage was provided by photo-chase aircraft on selected missions, and safety chase aircraft were utilized to record external phenomena during gun fire.

SYSTEM CHECKS

The gun gas purge system of the aircraft was checked before and after each flight to assure proper operation during firing.

The effects of vibration and "g" on the pullout plug and circuitry of the B-28 internal weapon were checked by monitoring the T-249 panel during flight and inspection of pullout plug after each flight.

CONDUCT OF TEST

The test was divided into two phases: aerial firing and ground firing. Throughout both phases, the nose section was checked for cracks by a series of dye-penetrant checks. These checks were performed before the test was started and after 18,000, 23,000, 28,000, 33,000, and 40,000 rounds were fired.

AERIAL FIRING. Aerial-firing missions (see Appendices I and II) were conducted with airspeeds ranging from mach 0.60 to mach 1.82, g loadings from -1/2 to 5 g's, and at altitudes varying from 3,000 to 40,000 ft. The aerial missions simulated all expected combat maneuvers such as Immelmanns, rolls, chandelles, turns and 20°, 30°, and 40° dives with 4- and 5-g pullups. During aerial firing, 29,459 rounds of ammunition were expended.

GROUND FIRING. This phase was conducted concurrently with the aerial firing phase. In this phase, the gun was boresighted, and improvements in the basic system design (see Description, Section 2 of this report) were tested. During ground firing, 10,710 rounds were fired.

SECTION 4 - TEST RESULTS AND DISCUSSION

STRUCTURAL COMPATIBILITY

CRACKS IN SECONDARY STRUCTURAL MEMBERS. There were no detectable indications of structural fatigue until the 33,000-round, dye-penetrant test. At this time, a small crack was noticed in one of the secondary structural members in the FF-3 compartment (Republic Aviation Corporation P/N 79F130031-57). Since dye-penetrant checks were performed at 0, 18,000, 23,000, 28,000, 33,000, and 40,169 rounds, the discovery of a crack at the 33,000-round check indicates that the crack must have started between 28,000 and 33,000 rounds of firing.

The crack in P/N 79F130031-57 was located in the bend radii between the fourth and fifth rivet from the skin of the aircraft. The crack at this stage was 1 in. long and was not hampered in any way from propagating. This was done specifically to determine if the crack would grow under both the dynamic and static loads that would be imposed by the remaining aerial and static ground-firing missions.

During subsequent testing the crack propagated diagonally across one end, resulting in a "T" effect. The diagonal branch of the crack was 3/16-in. long and approximately 30° to the original crack (Fig. 2).

EXPANDED FLAME PATTERN. An operational peculiarity was apparent during the test; this was the appearance of an expanded flame pattern (Fig. 3). This pattern, which is roughly elliptically-shaped (8 ft on the major axis and 4 ft on the minor axis), is caused by a mixture of gun gases and air. The flame pattern, sometimes coupled with engine surges, limited itself to a dynamic pressure range (q)* of 405 lb/ft^2 to 926 lb/ft^2, although it occurred randomly within this range.

There was no aircraft damage attributed to this flame pattern; however, the pattern was of sufficient intensity to distract the pilot during daylight flights and, therefore, may be a major cause of concern during night aerial-firing missions.

OPERATIONAL COMPATIBILITY

During the test it was noted that when firing the M61 gun at certain conditions of airspeed, altitude, and "g" loading, the pilot would feel successive engine surges. This surging is caused by engine ingestion of gun gases.

This problem is not new to the F-105D, but the effects of gun gas ingestion were supposed to be alleviated by installing the fuel purge line and air turbine motor accumulator as outlined in Time Compliance Technical Orders 1F-105-576 and 1F-105-553, respectively. Compliance

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* *Dynamic Pressure is defined as* $q\ (lb/ft^2) = \frac{1}{2} \rho V^2$

Where

ρ = *density in slugs/ft*^{3}

V = *velocity in ft/sec*

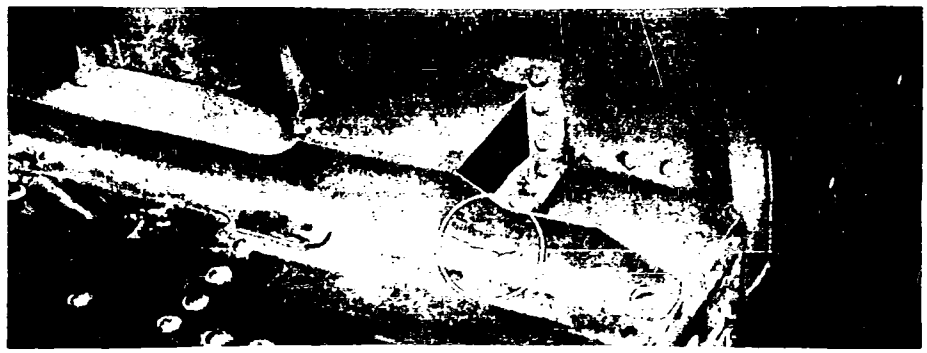


Fig. 2: Structural Cracks in FF-3 Compartment, P/N 79F130031-57.

with these technical orders was accomplished in the test-bed aircraft; however, the problem still persisted.

Although mild engine surging is to be expected while firing, some severe engine surging was encountered. This severe surging was of sufficient intensity to pull rivets from the variable air intake (VAI) plugs and to rupture the intake duct and the compressor conical fairing for the engine. Fig. 4 illustrates typical damage to the conical fairing. During the latter part of the test, compressor fairing stiffeners (Republic Aviation Corporation P/N 79P600025-11) were installed. These stiffeners were designed to protect the aft end of the compressor fairing from damage by keeping it from contact with engine bolts.

The severe surges were encountered at the following conditions:

Condition 1: Airspeed: Mach 0.86
Altitude: 7000 ft
G Loading: + 4 g's
q (Dynamic Pressure): 896 lb/ft^2 [Fig. 4(A)]

Condition 2: Airspeed: Mach 1.40
Altitude: 30,000
G Loading: + 5 g's (Right Turn)
q (Dynamic Pressure): 866 lb/ft^2 [Fig. 4(B)]

The following were typical changes in instrument readings encountered during severe engine surges over a 0.4-sec to 0.6-sec time interval:

Fuel Flow: From stabilized 12,000 lb/hr to 3,200 lb/hr

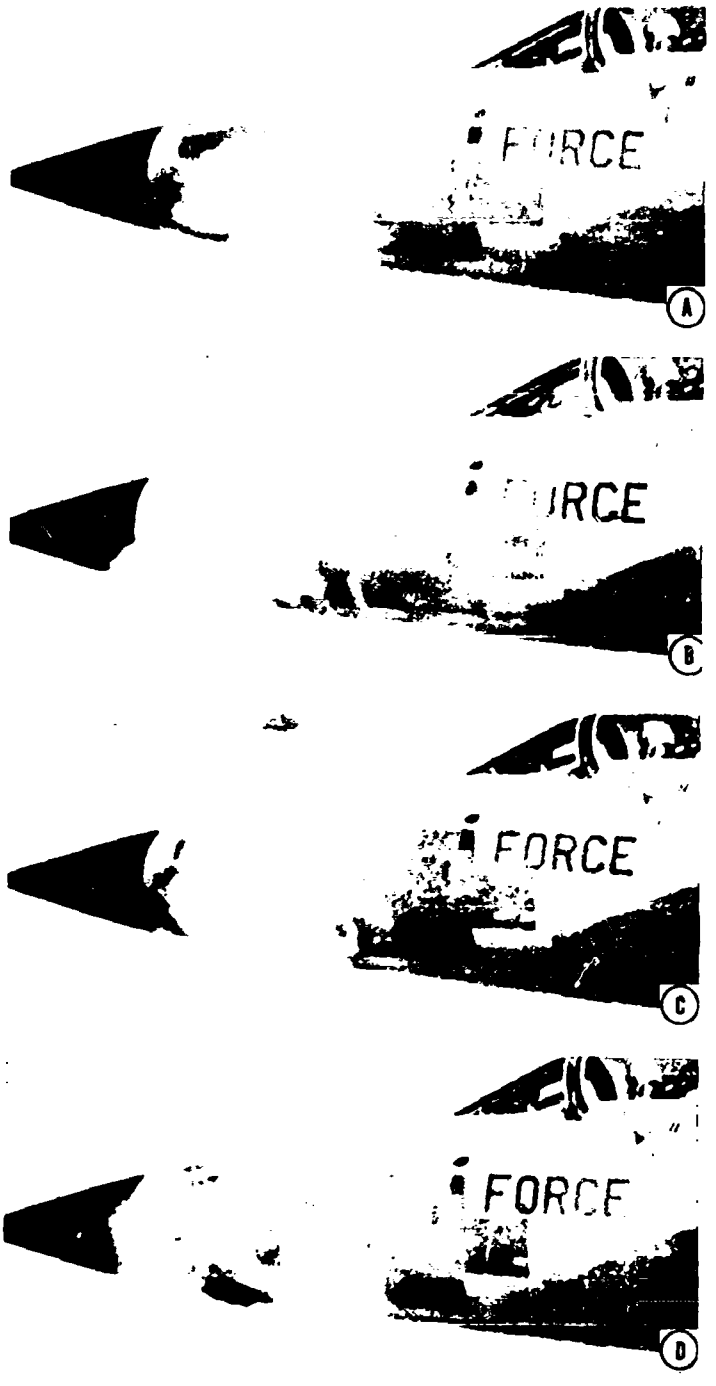


Fig. 3: Typical Flame Pattern Sequence, Showing (A) Ignition, (B) Burn, (C) First Stage Dissipation, and (D) Second Stage Dissipation.

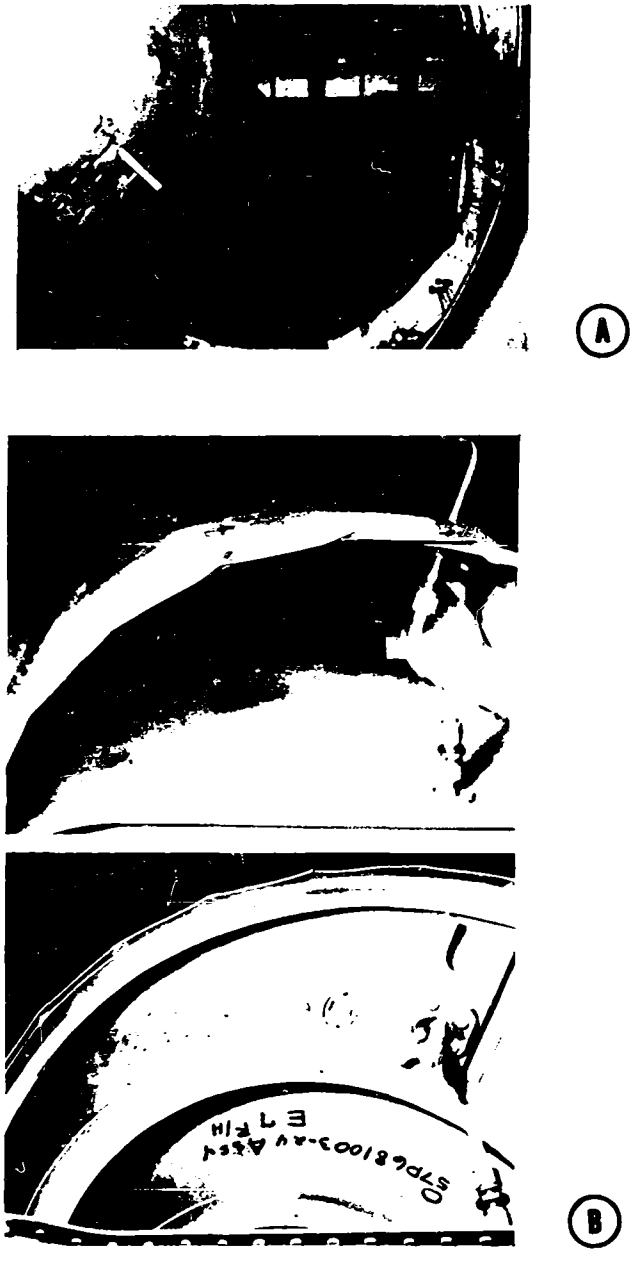


Fig. 4: Compressor Fairing Damage Caused by Severe Engine Surge, Showing (A) Condition 1 and (B) Condition 2.

Exhaust Pressure Ratio: From stabilized 2.0 to 1.4
Tachometer: From stabilized 100% to 106.5% to 92%
Airspeed Indicator: Loss of 100 - 150 kt

Project pilots reported that the severe surges were accompanied by severe compressor stalls.

GUN-FIRING RATE

The average firing rate of the M61 gun/linkless feed subsystem, as installed in the F-105D aircraft, was found to be 5038 rounds/min (Fig. 5 and Appendix III).

MAINTAINABILITY

During the test:

1. When one component of the subsystem jammed, it usually caused other components of the subsystem to malfunction and thus required complete subsystem removal and checkout. This is exemplified in an element separation or chute failure.

2. An average of 134 man-hours was required to remove, repair, check out, and reinstall the subsystem.

3. Three complete linkless feed subsystems and two guns were utilized.

4. A total of 40, 169 rounds of 20mm ammunition were fired. This firing resulted in 14 system stoppages (9 air and 5 ground), yielding 2869 rounds of firing per stoppage. A total of 1876 man-hours were required to clear these stoppages. This was distributed as follows: 448 man-hours for removal and installation of the subsystem and 1428 man-hours of field maintenance support to repair and check out the subsystem. It must be stressed that these man-hours are in addition to the man-hours required for scheduled maintenance of the subsystem.

Table 1 lists the replacements required during the test.

Stoppage data on the subsystem are given in Table 2.

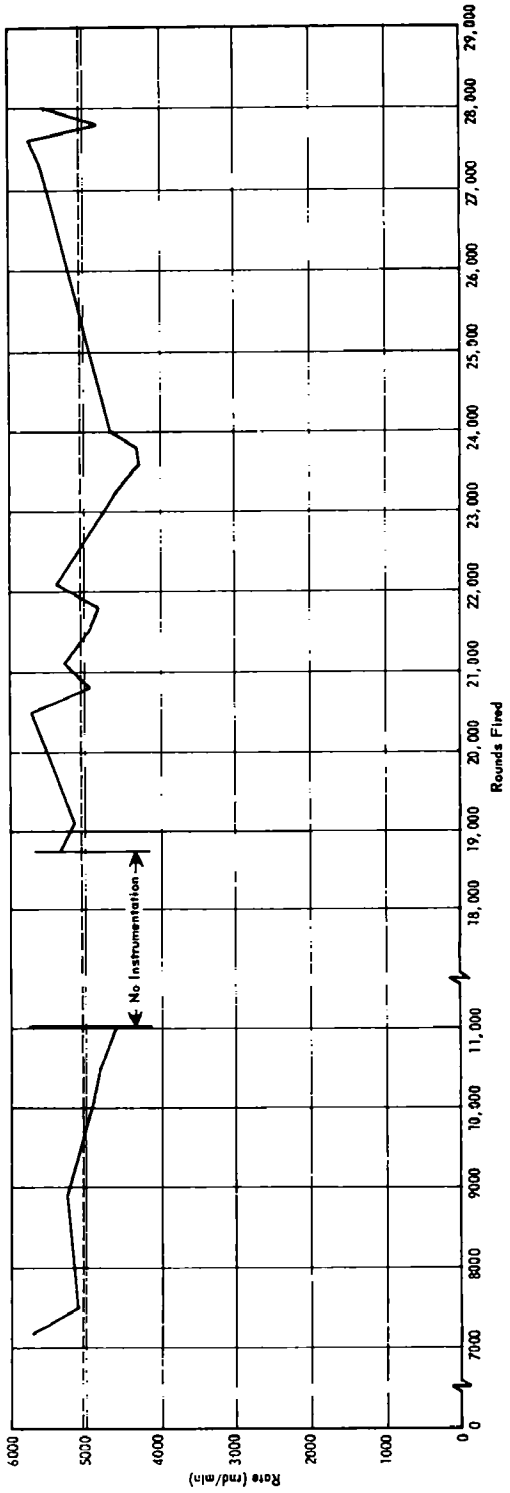


Fig. 5: Firing Rate for M61 Gun/Linkless Feed Subsystem (as installed in F-105D aircraft).

TABLE 1. REPLACEMENT DATA.

Item	Number of Replacements
Gun	4
Entrance Unit	10
Exit Unit	12
Transfer Unit	13
Drum	14
Elements	11 (142 elements per change)
Torque Tube	1
Gun Control Box	1
Return Chute	8
Feed Chutes	4
Bypass Chutes	5
Clearing Solenoid	1
Barrel Sets (Undercut Barrels)	5
Oilers	2
Front and Center Barrel Clamp	1 ea
Blast Tube	1
Flex Shaft Adapters	4

TABLE 2. DATA ON M61GUN/LINKLESS FEED SUBSYSTEM STOPPAGES.

Cause of Stoppage	Number Occurring	
	On Ground	In Air
Element Breakage	0	3
Link	1	0
Exit Unit	1	2
Entrance Unit	0	1
Transfer Unit	1	0
Return Cable	0	1
Round Out of Control	0	1
Drum (Flex Shaft Failure)	0	1
Double Feed	1	0
Loader	1	0

FUNCTIONAL ADEQUACY OF MODIFICATIONS

The following items were incorporated in the M61 gun/linkless feed subsystem to determine their usefulness and compatibility:

M61 gun oiler assembly
Gun firing interrupter switch
Gun firing interrupter relay
Modified blast tube
Undercut barrels
New elements

M61 GUN OILER ASSEMBLY. The oiler assembly operated satisfactorily during the test. This oiler experienced very little leakage and served to alleviate the requirement to lubricate the bolts after 1000 rounds of firing. The oiler is expected to last the life of the subsystem unless damaged during a gun subsystem jam.

GUN-FIRING INTERRUPTER SWITCH. Because of a necessary 0.75- to 2.0- sec delay (dependent on gun rate) between gun bursts to allow the gun to go into clearing, a gun-firing interrupter switch was installed in the system. This was proposed because of reported cases from the field which indicated that efforts were being made to fire successive bursts without waiting the necessary time, thus jamming the system. A gun-firing interrupter microswitch was tested in two modified forms. This switch was mounted on the gun housing and was mechanically tripped by the clearing cam. This switch did not function because of its sensitivity to vibration which caused the microswitch to close prematurely, cutting off gunfire. Due to the shortcomings of this switch, a redesign was accomplished by the contractor. The redesign resulted in the gun-firing interrupter relay.

GUN-FIRING INTERRUPTER RELAY. This relay is located adjacent to the gun-firing control box and satisfactorily provides the proper delay time between bursts, even though the pilot may inadvertently depress the trigger before the proper amount of time has elapsed. Based on the results of limited static ground testing, the gun-firing interrupter relay appears to operate satisfactorily.

MODIFIED BLAST TUBE. The blast tube initially installed in the test-bed aircraft was composed of tungsten plate that was channel-shaped in cross section. The life of this tube was approximately 7,000 - 10,000 rounds before a hot spot formed, and the plate was burned through by the gun gases. This problem was expensive and contributed to the maintenance hours needed to support the subsystem; therefore, the

contractor was requested to redesign the blast tube. The redesigned blast tube was not altered in material composition; however, it was redesigned in cross section. The new cross section is C-shaped and alleviated stagnant flow areas which produced hot spots.

The tube lasted 28,000 rounds until it was pierced by a projectile fired out of position. At this time the blast tube did not show any signs of wear.

UNDERCUT BARRELS. The undercut barrels utilized in this test eased the maintenance of the gun subsystem by allowing the muzzle stabilizer to be removed with less difficulty after carbon had formed on the barrels. However, it was determined that the undercut was not continued far enough. The present barrels are undercut 0.524 in. forward of the shoulder and should be undercut 0.458 in. forward of the shoulder.

NEW ELEMENTS. The elements initially intended for use in the subsystem had demonstrated the tendency to deform their flat-headed rivets through normal usage. When the rivet heads on the short loop of the element deformed, they would catch the long loop of the element causing a jam.

New elements with countersunk rivets in the short loop were available during the last 7000 rounds of firing. Based on this limited test, these elements appear to be superior to the old type.

ADEQUACY OF TECHNICAL ORDER 1F-105D-6

Technical Order 1F-105D-6 is adequate for the M61 gun/linkless feed subsystem except in the area of the linkless feed subsystem elements. At present, the technical order states that elements are usable for 12,000 - 15,000 rounds. During the test, a 3000-round inspection was found necessary.

EFFECTS OF FIRING ON B-28 INTERNAL NUCLEAR WEAPON

The B-28 internal nuclear weapon was subjected to 13 different firing conditions (reference Appendix III). During this period, the weapon was subjected to 17,072 rounds of firing. There were no signs of damage to the pullout plug or the monitoring circuit of the bomb.

SECTION 5 - CONCLUSIONS

It is concluded that:

1. The nose structure of the F-105D suffered no significant structural damage as a result of firing 40,000 rounds utilizing the M61 gun/linkless feed subsystem.

2. The M61 gun/linkless feed subsystem is not compatible with F-105D aircraft at certain points in the performance envelope of the aircraft. If firing takes place at these points, the aircraft will suffer severe engine surges with associated intake duct damage.

3. The subsystem experienced one stoppage for each 2869 rounds fired.

4. An average of 134 man-hours (including field-level work) was required to clear a gun jam and place the subsystem back in commission.

5. The average firing rate sustained by the Block IV M61 gun and linkless feed subsystem, as installed in the F-105D, was 5038 rounds per minute.

6. The undercut barrels eased the maintenance on the subsystem.

7. The oiler is useful in reducing system maintenance time.

8. The gun-firing relay, mounted adjacent to the gun-firing control box, appears to provide adequate protection for the system to prevent a jam if the pilot does not wait the required clearing time between bursts.

9. Gun vibration, coupled with "g" loading, does not affect the pullout plug retaining mechanism of the B-28 internal nuclear weapon.

10. The flame pattern produced by the mixing of gun gases and air produces a flash which is distracting to the pilot.

11. The new C-shaped blast tube did not show any signs of wear after 28,000 rounds of gun firing.

SECTION 6 - RECOMMENDATIONS

APGC Recommendations:	SPO Comments:
1. The F-105D be restricted from gun firing at the following conditions: Condition 1: Airspeed: Mach 0.86 Altitude: 7000 ft G Loading: +4 g q (Dynamic Pressure): 896 lb/ft^2 Condition 2: Airspeed: Mach 1.40 Altitude: 30,000 ft G Loading: +5 g (Right Turn) q (Dynamic Pressure): 866 lb/ft^2 If severe surging occurs anywhere in the flight envelope during gun firing, the pilot should discontinue the mission.	1. The SPO will direct insertion of a WARNING note in the pilot's handbook regarding action to be taken if engine surging is encountered during gun firing. The SPO does not concur in the gun fire restriction. Using Commands have been advised by SPO message of the problem encountered during firing at listed parameters.
2. Engine compressor fairing stiffeners (Republic Aviation Corporation P/N 79P600025-11) be retrofitted on all F-105D (-15RE and earlier) to prevent damage to the aft end of the compressor fairing during engine surging.	2. Concur. MOAMA will be directed to initiate retrofit action per recommendation.
3. If an engine surge is experienced during flight, the intake ducting and VAI plugs be inspected after flight for cracks and pulled rivets.	3. Concur. MOAMA will be requested to disseminate this information to the field via changes to maintenance technical orders.
4. The maintenance man-hour requirement for the subsystem be reduced.	4. Concur. Action is underway to provide a "soft" link and a "short" round to be used with this system. Both items are expected to materially reduce man-hours required to support this subsystem.

5. The undercut on the barrels be changed from 0.524 in. forward of the shoulder to 0.458 in. forward of the shoulder.	5. Concur. The SPO will request incorporation of this change as soon as possible.
6. The oiler be retrofitted on all subsystems in the field.	6. Concur. An engineering change proposal to provide the oiler for all aircraft will be requested by the SPO.
7. The gun-firing relay, mounted adjacent to the gun-firing control box, be retrofitted to all subsystems in the field.	7. Concur. An engineering change proposal is in preparation to provide the gun-firing interrupter relay. The retrofit of all aircraft is planned.

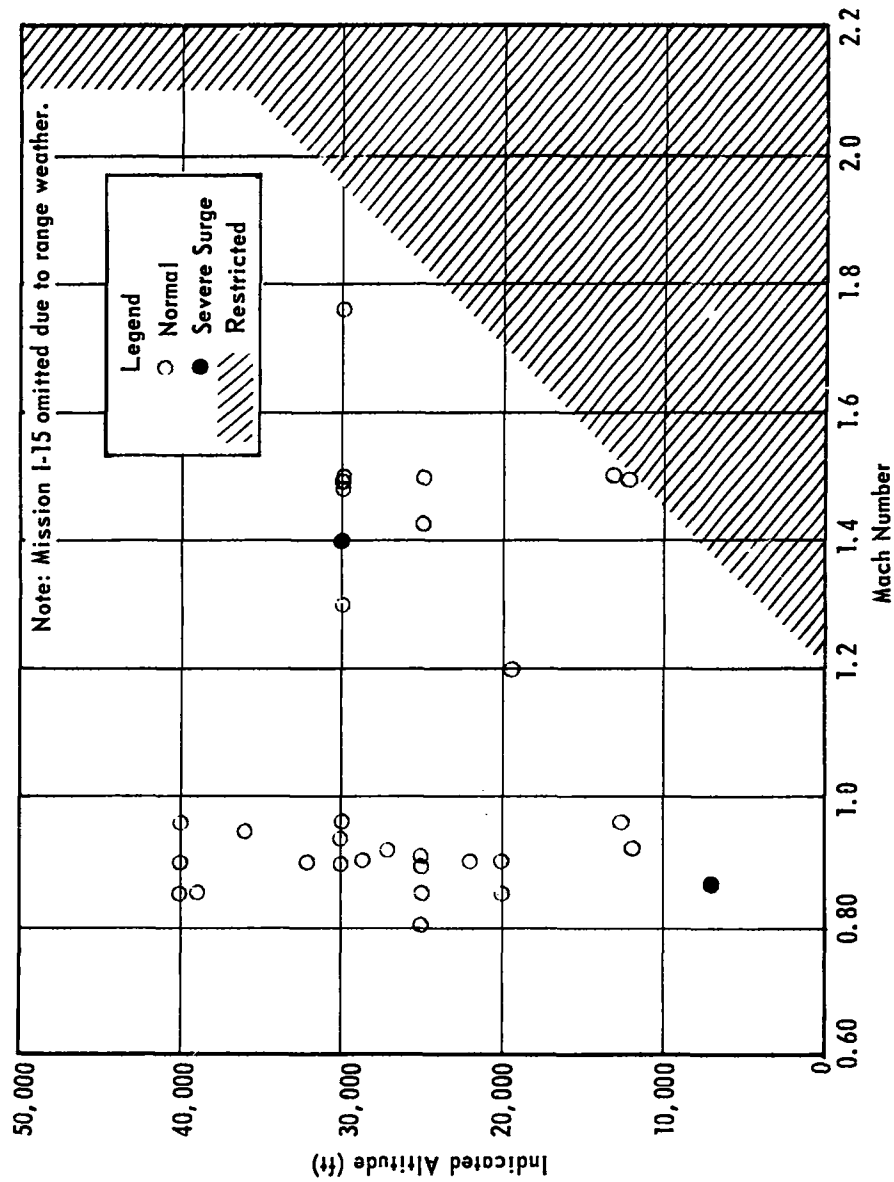
APPENDIX I

FLIGHT TEST DATA

Mission	Mach Number	Altitude (ft)	G Loading	Dynamic Pressure (lb/ft^2)	Comments
I-1	0.86	25,000	1.0	405	Caution light during g left yaw
	0.86	15,000	1.0	620	Slight engine surge
I-2	0.86	25,000	1.0	405	Engine surge; B-28 carried
I-3	0.86	15,000	1.0	620	B-28 carried
I-4	0.80	25,000	1.0	351	Engine surge during g left yaw; B-28 carried
	0.80	25,000	1.0	351	Flame pattern, engine surge; B-28 carried
I-5	0.90	20,000	1.0	554	Engine surge; B-28 carried
	0.90	20,000	0.0	554	Engine surge; B-28 carried
I-6	0.90	32,000	1.0	391	B-28 carried
	0.85	20,000	1.0	389	B-28 carried
	0.95	35,000	1.0	423	B-28 carried
	0.90	22,000	1.0	433	B-28 carried
I-7	0.86	25,000	1.0	405	Engine surge; B-28 carried
	0.86	15,000	1.0	620	B-28 carried
I-8	1.50	25,000	1.0	1249	B-28 carried
	1.46	25,000	1.0	1100	B-28 carried
I-9	0.86	25,000	1.0	406	Engine surge; B-28 carried
	0.80	25,000	1.0	331	Caution light; engine surge during yaw left; B-28 carried
I-10	0.86	5,000	1.0	916	B-28 carried
	0.86	5,000	4.7	916	B-28 carried
	0.70	17,000	1.0	380	Flame pattern
I-11	0.90	40,000	1.0	176	B-28 carried
	0.90	27,000	1.0	400	B-28 carried
	0.90	20,000	1.0	554	B-28 carried
I-12	0.90	20,000	0.0	554	Engine surge; B-28 carried
I-13	0.86	5,000	1.0	916	B-28 carried
	0.86	12,500	1.0	362	Engine surge; B-28 carried
I-14	1.75	30,000	1.0	1515	B-28 carried
	0.89	30,000	1.0	393	Engine surge; B-28 carried
	0.89	25,000	1.0	410	Engine surge; aft boost pump light; B-28 carried
I-15	Range wx				
I-16	0.85	40,000	1.0	343	B-28 carried
	0.84	39,800	1.0	333	B-28 carried
	0.90	20,000	1.0	554	B-28 carried
I-17	0.90	25,000	1.0	446	Engine surge; B-28 carried
	0.90	25,000	1.0	446	Engine surge; B-28 carried
I-18	0.90	30,000	1.5	400	Engine surge - right optical; B-28 carried
	0.90	25,000	3.5	418	B-28 carried
I-19	1.2	20,000	5.0	780	B-28 carried
	1.4	15,500	4.7	1093	B-28 carried
I-20	1.5	30,000	5.0	993	B-28 carried
	0.95	17,500	1.0	681	B-28 carried
	1.5	15,500	5.0	1330	B-28 carried

Mission	Mach Number	Altitude (ft)	G Loading	Dynamic Pressure (lb/ft^2)	Comments
I-21	1.5	30,000	4.8	995	B-28 carried
	1.5	30,000	4.9	995	B-28 carried
	0.95	17,500	1.0	681	B-28 carried
	1.5	12,000	5.0	2123	Engine surge; B-28 carried
I-22	1.5	15,000	1.0	1940	30° dive
	1.5	11,000	3.5	2218	Pullup into Immelmann
	0.90	36,000	1.0	308	Pullout on top of Immelmann
	0.80	25,000	1.0	331	
I-23	0.86	5,000	1.0	945	
	0.90	3,000	1.0	1075	
	0.90	5,000	3.75	1005	Severe engine surge on 3.75 g pullup
	0.96	15,000	2.5	568	Top of Immelmann
I-24	0.90	20,000	1.0	554	
	0.90	20,000	3.0	554	
	0.90	20,000	1.0	554	
I-25	0.86	5,000	1.0	945	
	0.90	4,600	1.0	1020	
	0.86	7,000	4.0	896	Three severe engine surges
	0.80	17,000	1.0	495	
	0.80	25,000	1.0	331	Engine surge during right yaw
I-26	0.80	25,000	1.0	331	Engine surge, master caution light
	0.80	25,000	1.0	331	Engine surge
I-27	Interrupter switch malfunction				
I-28	0.90	35,000	3.5	357	Left spiral
	0.90	27,000	2.5	409	Chandelle left
	0.90	35,000	3.0	357	Right spiral
	0.90	27,000	3.5	409	Chandelle right
I-29	0.96	40,000	1.0	254	30° dive
	0.96	30,000	1.0	865	30° dive
	0.90	40,000	1.0	224	30° dive
	0.93	35,000	1.0	384	30° dive
I-30	1.45	30,000	1.0	931	
	1.50	30,000	1.0	996	
	1.50	30,000	1.0	996	
	1.50	25,000	1.0	1240	
I-31	1.5	30,000	1.0	996	
	0.90	28,000	1.0	390	
	0.90	28,000	1.0	390	
	0.90	28,000	1.0	390	
I-32	1.5	30,000	5.0	996	
I-33	1.4	30,000	5.0	886	Severe engine surge, ½-g right turn
	1.5	30,000	1.0	996	
	1.2	19,000	5.0	1281	

APPENDIX II
GUN-FIRING FLIGHT DATA FOR F-105D, SN 58-1147



APPENDIX III
GUN-FIRING DATA

In this appendix, the average firing rate of the gun is defined as the rate of the gun (including acceleration) over the first 2 sec of firing. This does not include deceleration time if this occurs during the first 2 sec of firing.

If the sample size of the burst is not 2 sec, the average peak rate (does not include acceleration time) will be determined and the number of rounds extrapolated to 2 sec.

All rounds will be counted to the nearest tenth for the purposes of accuracy.

Date	Flight Number*	Run Number	Rounds Fired	Firing Rate		Total Rounds Fired			B-28 Carried
				Average	Steady State	Aircraft	Gun	Linkless Feed System	
20 Nov 61	G-1	-	1196	No Instrumentation		1196	1196	1196	No
14 Nov 61	I-1	1	130	Instrumentation	Malfunction	1326	1326	1326	No
		2	186	Instrumentation	Malfunction	1412	1412	1412	No
		3	190	Instrumentation	Malfunction	1602	1602	1602	No
		4	468	Instrumentation	Malfunction	2070	2070	2070	No
3 Dec 61	G-2	1-5	967	No Instrumentation		3037	3037	3037	No
11 Dec 61	G-3	1	140	5950	6012	3177	3177	140	No
		2	41	Too Short		3218	3218	181	No
		3	67	Too Short		3285	3285	248	No
		4	149	5970	6036	3434	3434	397	No
		5	360	6000	6060	3794	3794	757	No
		6	140	5965	6030	3934	3934	897	No
		7	70	Too Short		4104	4104	967	No
29 Jan 62	I-2	1-2	461	No Instrumentation		4632	4632	1428	Yes
30 Jan 62	I-3	1-2	528	No Instrumentation		5093	5093	528	Yes
31 Jan 62	I-4	1-5	828	No Instrumentation		5921	5921	1356	Yes
2 Feb 62	I-5	1-5	1000	No Instrumentation		6921	6921	2356	Yes
5 Feb 62	I-6	1	190	5700		7211	7211	2546	Yes
		2	172	5150		7383	7383	2718	Yes
		3-5	616	No Instrumentation		7999	7999	3334	Yes
5 Feb 62	I-7	1-4	980	No Instrumentation		8979	8979	4314	Yes
6 Feb 62	I-8	1-5	980	5295 4910		9959	9959	5294	Yes
6 Feb 62	I-9	1-5	980	4750 4560		10, 939	10, 939	6274	Yes
7 Feb 62	I-10	1-5	978	No Instrumentation		11, 917	11, 917	7252	Yes
7 Feb 62	I-11	1-5	986	No Instrumentation		12, 903	12, 903	8238	Yes
5 Mar 62	I-12	1-12	991	No Instrumentation		13, 894	13, 894	991	Yes
5 Mar 62	I-13	1-4	980	No Instrumentation		14, 874	14, 874	1971	Yes
6 Mar 62	I-14	1-5	980	No Instrumentation		15, 854	15, 854	2951	Yes
8 Mar 62	G-4	1-5	981	No Instrumentation		16, 835	16, 835	973	No
	G-5	1-5	973	No Instrumentation		17, 808	17, 808	1954	No
9 Mar 62	I-16	1-5	991	5320		18, 799	18, 799	991	Yes
9 Mar 62	I-17	1-3	568	5040		19, 367	19, 367	1559	Yes
12 Mar 62	I-18	1-5	978	5640		20, 345	20, 345	978	Yes
12 Mar 62	I-19	1-5	324	4944		20, 669	20, 669	1292	Yes
			345	5210		21, 014	21, 014	1637	Yes
			312	4965		21, 326	21, 326	1959	Yes
14 Mar 62	I-10	1	179	4764		21, 505	21, 505	2138	Yes
		2	192	5061		21, 697	21, 697	2330	Yes

Date	Flight Number*	Run Number	Rounds Fired	Firing Rate		Total Rounds Fired			B-28 Carried
				Average	Steady State	Aircraft	Gun	Linkless Feed System	
14 Mar 62 (Continued)		3	162	5196		21,859	21,859	2492	Yes
		4	183	5310		22,042	22,042	2675	Yes
		5	58	-		22,100	22,100	2733	Yes
		6	150	Oscilliograph Not On		22,250	22,250	2883	Yes
15 Mar 62	I-21	I-7	780	No Instrumentation		23,030	23,030	3513	Yes
16 Mar 62	I-22	1	257	4500		23,287	23,287	3770	Yes
		2	188	4210		23,475	23,475	3958	Yes
		3	222	4250		23,697	23,697	4190	Yes
		4	251	4521		23,948	23,948	4441	Yes
		5	55			24,003	24,003	4496	Yes
21 Mar 62	I-22	1	250	No Instrumentation		24,253	24,253	250	No
		2	289	No Instrumentation		24,542	24,542	539	No
		3	327	No Instrumentation		24,869	24,869	866	No
		4	123	No Instrumentation		24,992	24,992	989	No
23 Mar 62	I-24	1	292	No Instrumentation		25,384	292	292	No
		2	272	No Instrumentation		25,656	564	564	No
		3	276	No Instrumentation		25,932	840	840	No
		4	131	No Instrumentation		26,063	971	971	No
4 Apr 62	I-25	I-4	975	No Instrumentation		27,038	1946	1946	No
9 Apr 62	I-26	1	254	5612		27,292	2200	2200	No
		2	231	5591		27,523	2431	2431	No
		3	205	4839		27,728	2636	2636	No
		4	145	5550		27,873	2781	2781	No
14 May 62	I-27	I-4	10	Too Short		27,883	2791	2791	No
	I-27	I-5	885	No Instrumentation		28,768	3676	3676	No
15 May 62	I-28	I-5	980	No Instrumentation		29,748	4656	4656	No
	I-29	I-5	980	No Instrumentation		30,728	5636	5636	No
	I-30	I-5	980	No Instrumentation		31,708	6616	6616	No
	I-31	I-5	980	No Instrumentation		32,688	7596	7596	No
9 Jul 62	I-32	I-5	980	No Instrumentation		33,668	8576	980	No
10 Jul 62	I-33	I-5	975	No Instrumentation		34,643	10,521	1945	No
11 Jul 62	G-6	I-5	981			35,624	13,441	2920	No
12 Jul 62	G-7	I-4	590			36,214	590	590	No
13 Jul 62	G-8		992			37,206	992	992	No
	G-9		1007			38,213	1999	1999	No
	G-10		986			39,199	2985	2985	No
	G-11		970			40,169	3955	3955	No

* G - Ground-Firing Missions
I - Aerial-Firing Missions
I-16 aborted because of range weather.

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1	Hq USAF (AFCCS)	1	AFSWC (SWTOE)
1	Hq USAF (AFCOA)	1	AFSWC (SWVC)
1	Hq USAF (AFDRT-GW)	1	AFSWC (SWVN)
1	Hq USAF (AFMPP-WS)	1	AFSWC (SWVS)
1	Hq USAF (AFOOP)	1	AFSWC (SWVW)
2	Hq USAF (AFORQ)	1	AFSWC (SWOI)
1	Hq USAF (AFPDF)	1	AFFTC (FTFOF)
1	Hq USAF (AFPMP)	1	5AF (5FCAG-P)
1	Hq USAF (AFPTR)	2	9AF
1	Hq USAF (AFXPD)	2	12AF
1	Hq USAF (AFXPR)	1	13AF (130DO)
1	Hq USAF (AFSSA-AS)	1	13AF (MLP-P)
1	Hq USAF (AFCIN-3K2)	3	17AF (M-M1)
1	Dep IG for Insp (AFIPA)	2	19AF
4	AFLC (MCD)	2	831 Air Div
2	AFSC (SCPPT)	2	832 Air Div
1	AFSC (SCRA)	2	837 Air Div
1	ASD (LMDF)	1	3320th Tech Sch (TOT-3)
1	ASD (LMEC-3)	1	USAFE (OOT)
6	ASD (ASZF)	1	USAFE (OTREQ)
1	ASD (ASN)	6	7272 ABWg, USAFE Wpns Cen
2	TAC (DOC)	1	PACAF (PFMCD)
2	TAC (DM)	5	PACAF (PFODC)
2	TAC (DORQ)	1	PACAF (PFOOT)
2	TAC (DMEM)	1	PACAF (PFORQ)
2	TAC (DOOP)	1	MAAMA (MANE)
1	TAC (DOPL)	3	MOAMA (MONA)
1	TAC (DOTE)	1	OCAMA (OCNEW)
1	TAC (DOTR)	2	WRAMA (WRVPA)
1	TAC (DPL)	1	4 Tac Ftr Wg
1	TAC (IG)	2	18 Tac Ftr Wg
1	TAC (C)	1	27 Tac Ftr Wg
1	TAC (VC)	1	31 Tac Ftr Wg
1	TAC (TFW-TTS)	2	36 Tac Ftr Wg
1	SAC (O/A)	2	49 Tac Ftr Wg
1	SAC (DPLBC)	1	354 Tac Ftr Wg
1	ATC (ATTAT-F)	1	363 Tac R Wg
1	ATC (ATTWS)	1	401 Tac Ftr Wg
1	AAC (XPR)	1	474 Tac Ftr Wg
1	AAC (OA)	1	479 Tac Ftr Wg
1	USAF FWS (TFW)	1	4505 Air Rflg Wg

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5	8 Tac Ftr Sq
5	9 Tac Ftr Sq
5	12 Tac Ftr Sq
5	22 Tac Ftr Sq
5	23 Tac Ftr Sq
1	27 AEM Sq
1	31 AEM Sq
5	35 Tac Ftr Sq
5	36 Tac Ftr Sq
5	44 Tac Ftr Sq
5	67 Tac Ftr Sq
5	80 Tac Ftr Sq
1	306 Tac Ftr Sq
1	307 Tac Ftr Sq
1	308 Tac Ftr Sq
1	309 Tac Ftr Sq
1	333 Tac Ftr Sq
1	334 Tac Ftr Sq
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1	352 Tac Ftr Sq
1	353 Tac Ftr Sq
1	354 AEM Sq
1	355 Tac Ftr Sq
1	356 Tac Ftr Sq
1	401 AEM Sq
1	427 Air Refulg Sq
1	428 Tac Ftr Sq
1	429 Air Refulg Sq
1	429 Tac Ftr Sq
1	430 Tac Ftr Sq
1	431 Air Refulg Sq
1	434 Tac Ftr Sq
1	435 Tac Ftr Sq
1	436 Tac Ftr Sq
1	474 AEM Sq
1	476 Tac Ftr Sq
1	478 Tac Ftr Sq
1	479 AEM Sq
1	481 Tac Ftr Sq
1	522 Tac Ftr Sq
1	523 Tac Ftr Sq
1	524 Tac Ftr Sq
1	612 Tac Ftr Sq
1	613 Tac Ftr Sq
1	614 Tac Ftr Sq
1	615 Tac Ftr Sq
1	622 Air Refulg Sq
1	4425 Sch Sq
1	4521 CCr Tng Sq
1	4522 Fld Maint Sq
1	4523 CCr Tng Sq
1	4524 CCr Tng Sq
1	4525 Sch Sq (TFW-TTS)
1	4526 CCr Tng Sq
1	4528 ORGL Maint Sq
1	4529 ORGL Maint Sq
1	STRICOM (STRJ-3)
1	US Army War College
1	ABMA (ORDAB-HT)
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1	USNADC
1	Air Devel Sq FIVE
3	AU (AUL-9764)
1	Dir USAF Project RAND
2	AFPR Republic Avia Corp
1	North Amer Avia
15	ASTIA (TIPCR)
	APGC
30	PGAPI
2	PGBM
3	PGEH
1	PGML
1	PGVP
1	PGVSS-3
1	PGOPZ
4	PGZF
1	TACLO
4	RAC
1	PGAPT

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Air Proving Ground Center, Eglin Air Force Base, Florida
Rpt No. APGC-TDR-62-57. STRUCTURAL COMPATIBILITY TEST OF M61 GUN/LINKLESS FEED SUBSYSTEM AND F-105D AIRCRAFT. Final report. October 1962. 25p. incl. illus., tables. Unclassified Report

The M61 gun/linkless feed subsystem was designed to provide the F-105D with a compact, self-contained, high rate firing capability. The primary object of this test was to determine the effects of this subsystem on the structural integrity of the aircraft nose structure. As a result of this test, it is concluded that the subsystem imposes no serious structural limitations on the F-105D; however, because of the effects of gun gas, the firing envelope of the aircraft is limited. Modifications to the basic M61 gun/linkless feed subsystem (oiler, undercut barrels, modified blast tube, and interrupter relay) were tested and found to be satisfactory. There is a problem in maintaining the M61 gun/linkless feed subsystem since 134 man-hours are required to repair the subsystem after a stoppage occurs.

1. Aircraft, F-105D
2. Aircraft guns
3. M61
I. AFSC Project 306A
II. Panzarella, Philip P., 1st Lt., USAF
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